EXHIBIT D

MAOC-415000

Broadband VCO w/ Buffer Amplifier
10 - 20 GHz

Rev. V1

Features

- Octave Tuning Bandwidth
- Phase Noise: -90/-118 dBc/Hz @ 100 kHz/1 MHz
- V_{TUNE} Range: 0 - 23 V
- Low Current Consumption: 70 mA
- Excellent Temperature Stability
- +5 V Bias Supply
- Lead-Free 4 mm 24-Lead Package
- RoHS* Compliant and 260°C Reflow Compatible

Description

The MAOC-415000 is a wideband voltage controlled oscillator operating in the 10 - 20 GHz range. The VCO delivers flat output power via a high isolation buffer amplifier. The VCO exhibits very low phase noise over its operating conditions. A single +5 V bias voltage is required, and a tuning voltage of 0 - 23 V. The device is fully matched and no external matching components are required.

The MAOC-415000 has very low phase noise, stable output power over temperature and excellent tuning control, making it ideal for applications such as communications systems, test and measurement and wideband defense applications.

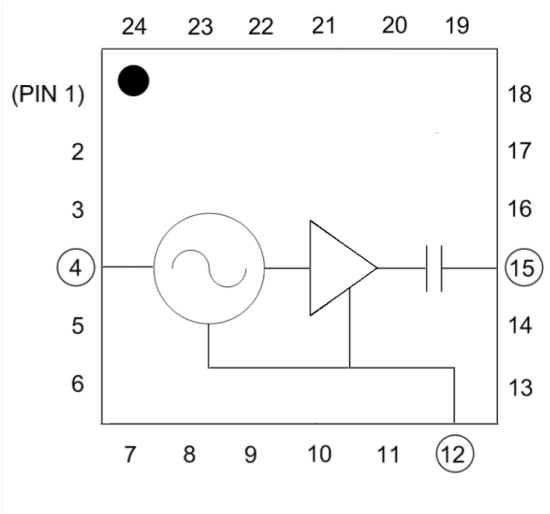
The 4 mm package has a lead-free finish that is RoHS compliant and compatible with a 260ºC reflow temperature. The package features low lead inductance and an excellent thermal path.

Ordering Information[1]

Part Number	Package
MAOC-415000-TR0100	100 Part Reel
MAOC-415000-TR0500	500 Part reel
MAOC-415000-001SMB	Sample Board

1. Reference Application Note M513 for reel size information.

Block Diagram



Pin Configuration[2]

Pin No.	Pin Name	Function
1 - 3	GND	Ground
4	V_{TUNE}	Tune Voltage
5, 6	GND	Ground
7	N/C	No Connection
8 - 11	GND	Ground
12	V_{CC}	Supply Voltage
13, 14	GND	Ground
15	RF	RF Output
16 - 18	GND	Ground
19	N/C	No Connection
20 - 23	GND	Ground
24	N/C	No Connection
25[3]	GND	Ground

2. Connecting all N/C and GND pins to RF/DC ground is also recommended.
3. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

* Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

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Electrical Specifications: T_A = 25°C, V_{CC} = 5 V[4], Z_0 = 50 Ω

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Output Power	RF Port, 10 - 20 GHz	dBm	—	6	—
SSB Phase Noise	RF Port, 10 kHz Offset, 10 - 20 GHz RF Port, 100 kHz Offset, 10 - 20 GHz RF Port, 1 MHz Offset, 10 - 20 GHz	dBc/Hz	—	-60 -90 -118	—
Harmonics	RF Port, $2F_o$	dBc	—	-20	—
Pulling (Sensitivity to Match)	RF Port, VSWR = 2:1	MHz pk-pk	—	12	—
Pushing (Sensitivity to Supply Voltage)	RF Port, 10 - 20 GHz	MHz/V	—	90	—
Frequency Drift Rate (Sensitivity to Temperature)	RF Port, 10 - 20 GHz	MHz/°C	—	1.0	—
Output Return Loss	RF Port, 10 - 20 GHz	dB	—	8	—
Supply Current	I_{CC}	mA	—	70	90
Tune Voltage	V_{TUNE}	V	0	—	23
Tuning Current Leakage	V_{TUNE} = 23 V	µA	—	5	—

4. VCO can operate over the 4.75 V to 5.25 V supply voltage range.

Absolute Maximum Ratings[5,6,7]

Parameter	Absolute Maximum
V_{CC}	+5.5 V
V_{TUNE}	25 V
Storage Temperature	-55ºC to +150ºC
Operating Temperature	-40ºC to +85ºC
Junction Temperature[8]	+135ºC

5. Exceeding any one or combination of these limits may cause permanent damage to this device.
6. MACOM does not recommend sustained operation near these survivability limits.
7. Operating at nominal conditions with $T_J \leq +135°C$ will ensure MTBF > 1 x 10^6 hours.
8. Junction Temperature (T_J) = T_C + Θjc * (V * I)
   Typical thermal resistance (Θjc) = 47° C/W.
   a) For T_C = 25°C, T_J = 41°C @ 5 V, 69 mA
   b) For T_C = 85°C, T_J = 101°C @ 5 V, 68 mA

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

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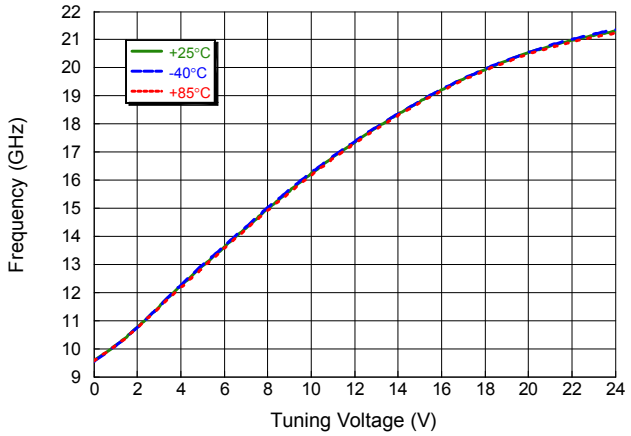
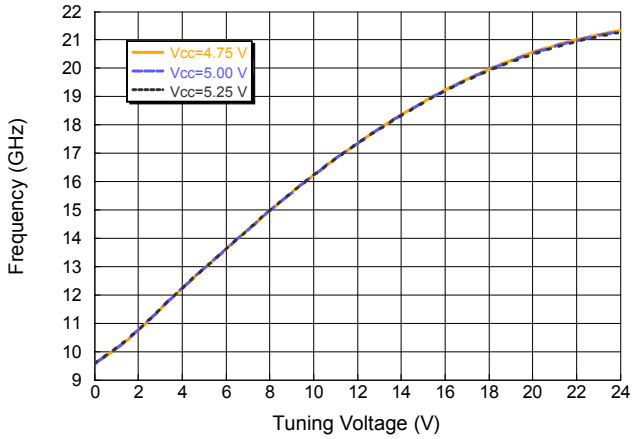
Typical Performance Curves: V_{CC} = 5 V, T_A=+25°C (unless otherwise indicated)

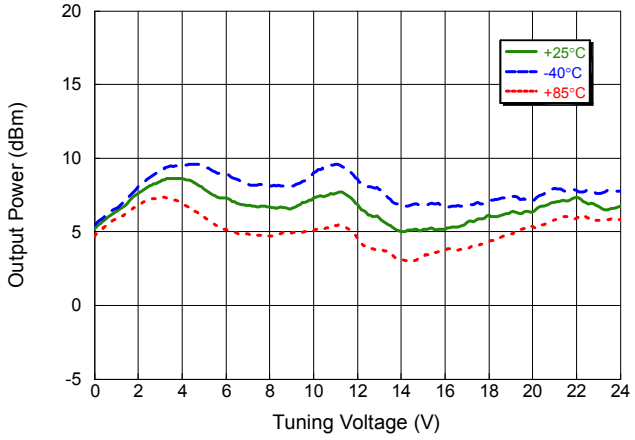
Output Frequency vs. Tune Voltage



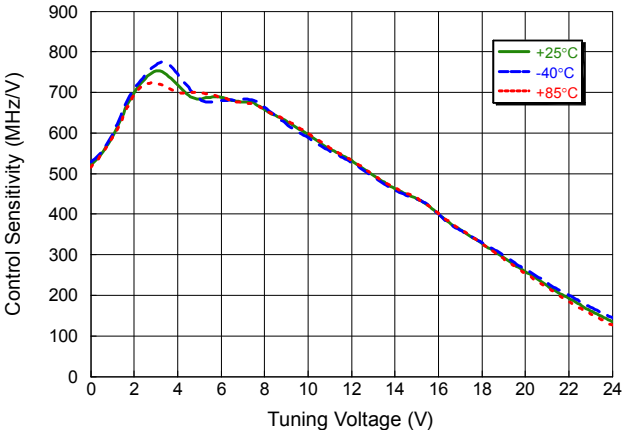
Output Frequency vs. Tune/Supply Voltage



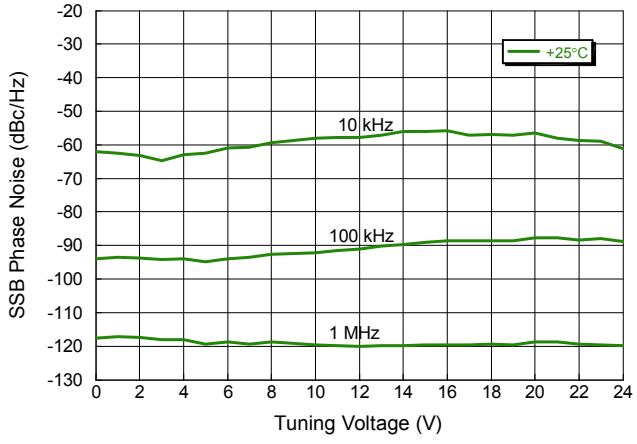
Output Power vs. Tune Voltage



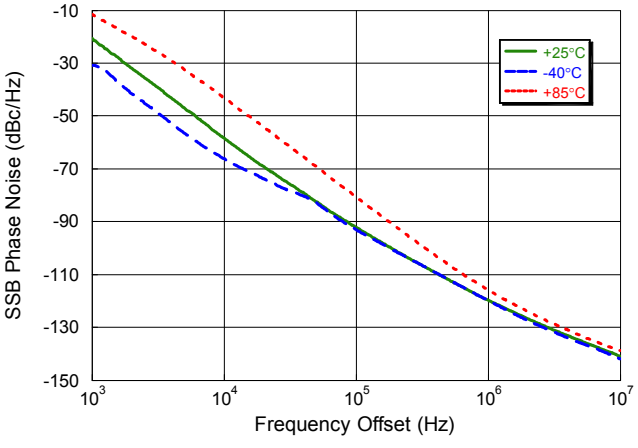
Control Sensitivity vs. Tuning Voltage



Phase Noise vs. Tune Voltage



Phase Noise vs. Frequency Offset (V_{TUNE} = 10 V)



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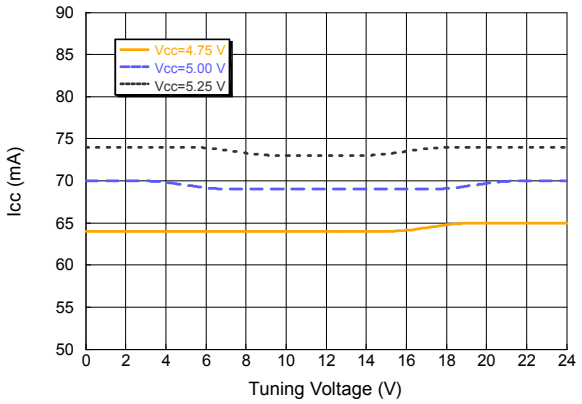
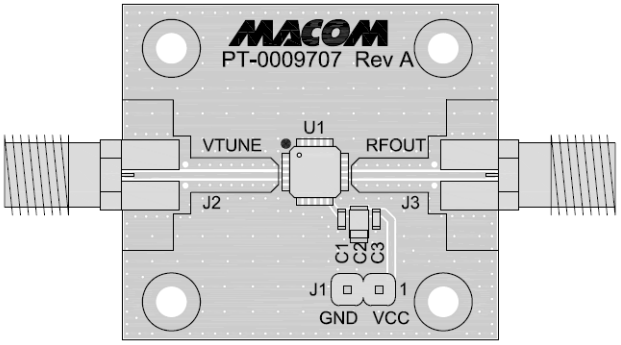
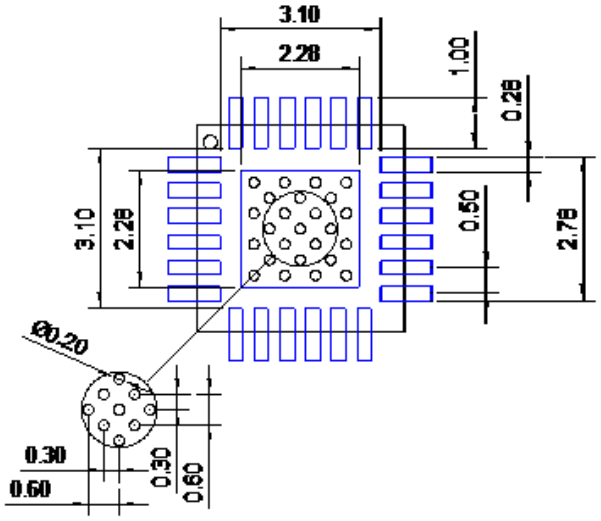
Supply Current vs. Tune/Supply Voltage



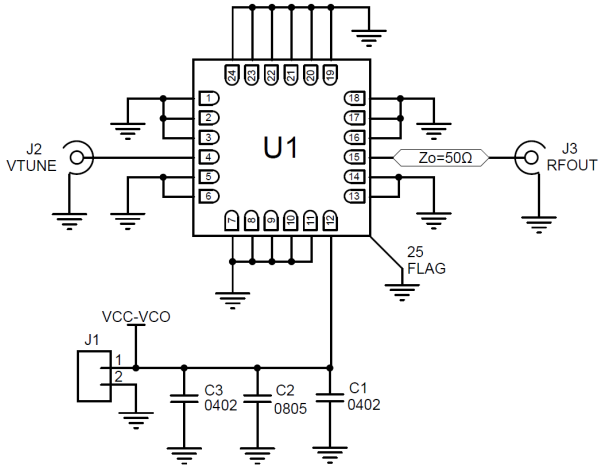
Recommended PCB Sample Board



PCB Land Pattern



Sample Board Schematic[9]

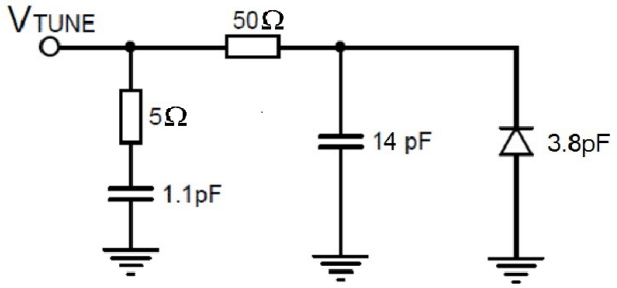
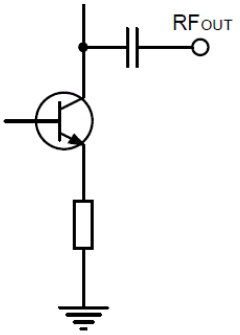
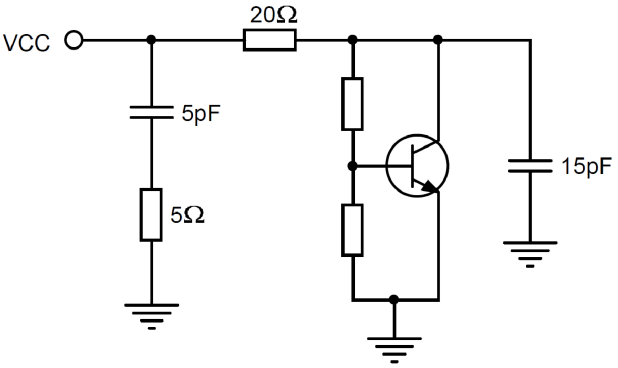


9. All N/C and GND pins should be connected to RF/DC ground.

Parts List

Component	Description
PCB	PT-0009707 SMB, 0.254mm Rogers RO4350B
U1	MAOC-415000
C1	CAP, 100 pF, 0402 Case size
C2	CAP, 10 µF, 0805 Case Size
C3	CAP, 0.1 µF, 0402 Case Size
J1	DC Header
J2, J3	RF Connector, SMA HF, Johnson

Pin Descriptions

Pin #	Function	Description	Equivalent Interface Schematic
7, 19, 24	N/C	No connect pins. These pins should be connected to RF/ DC ground.	
1-3, 5, 6, 8-11, 13, 14, 16-18, 20-23, 25	GND	Ground pins. These pins should be connected to RF/ DC ground.	
4	V_{TUNE}	VCO tune voltage input	
15	RF	VCO RF output. Internally DC blocked.	
12	V_{CC}	VCO supply voltage.	

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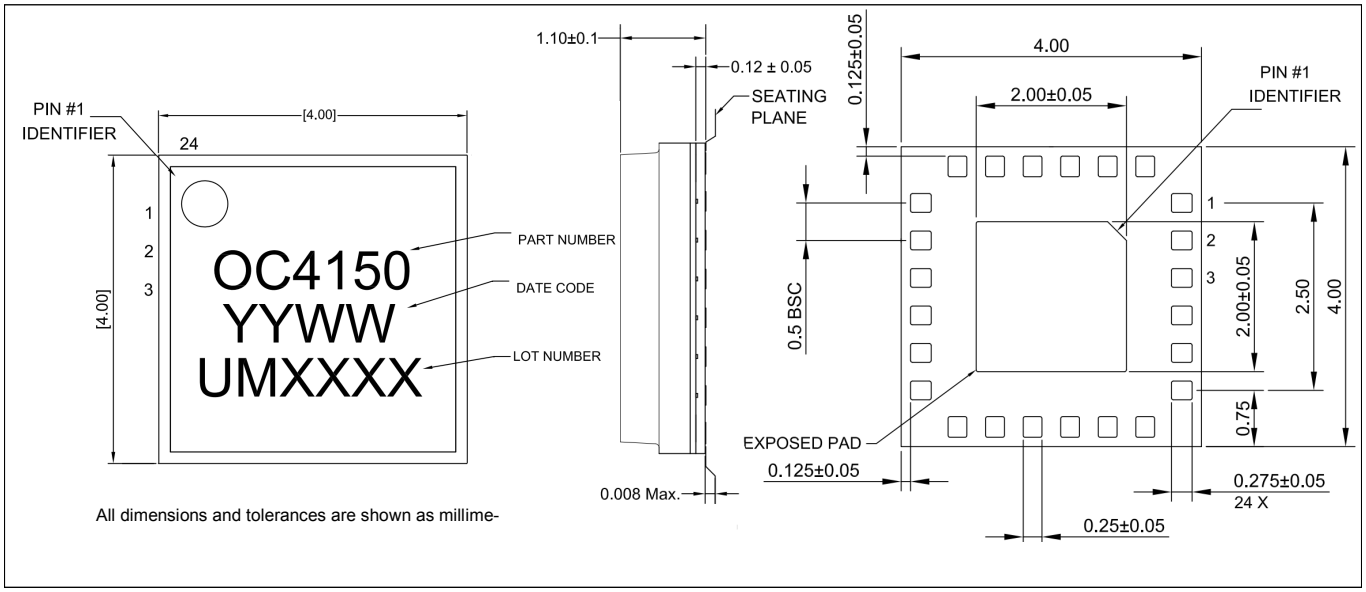
Lead-Free 4 mm 24-Lead AQFN Package†



† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is NiPdAu over Copper